

No repulsive force in General Relativity

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ABSTRACT

We show that a recent assertion that gravitational wave emission can lead to a repulsive force explaining the accelerated expansion of the Universe is totally unfounded.

Key words: gravitation — gravitational waves — cosmology: miscellaneous.

1 INTRODUCTION

In a recent paper Gorkavyi & Vasilkov (2016) asserted that “reduction of the gravitational mass of the system due to emitting gravitational waves leads to a repulsive gravitational force” and that in the cosmological context this implies that “mergers of inhomogeneities like black holes, resulting in emission of gravitational waves, can generate a repulsive gravitational force (...). These mergers act as effective dark energy, if the total mass of the universe is decreased”. They conclude that “This may imply that big bang and accelerated expansion of the Universe is not related to current processes in the Universe but to a relict repulsive gravitational force or to a configuration of space-time that originates in the previous cycle of the Universe when at the last stage of a collapse the intensive generation of gravitational waves resulted in a sharp decrease of the gravitational mass of the Universe (...).” In this note we will show that these assertions are mistaken: there is no repulsive force in General Relativity, and the effect the authors have in mind cannot contribute to the accelerated expansion of the Universe.

2 NO REPULSION AND NO ACCELERATION

It is obvious that what Gorkavyi & Vasilkov (2016) call a “repulsive force” is simply the result of decreasing *Newtonian* gravitational attraction when gravitating bodies loose mass. From this trivial fact Gorkavyi & Vasilkov (2016) drew cosmic conclusions. They used a model of the Universe which is thought of as a finite sphere; radiation may leave it so its “total mass” decreases. The model, despite a relativistic make-up¹, is basically Newtonian. This is why

terms that are meaningless in Einstein’s theory, such as “the (cosmological) gravitational force” or “the total mass of the Universe”, are used.

Gorkavyi & Vasilkov (2016) consider gravitational waves as the only agent that decreases the mass of radiating objects; they do not explain why they neglect electromagnetic radiation – after all, stars radiate, losing gravitational mass, which (by the authors’ logic) should also lead to a “decrease of the total mass of the Universe” and “repulsive gravitational forces”. The electromagnetic radiation effect should be (by the authors’ own logic) even stronger than the gravitational wave (GW) effect they discuss, because the cosmological parameter $\Omega_{GW} \sim 10^{-9}$ for gravitational waves (Abbott et al. 2016) is more than two orders of magnitude smaller than that corresponding to infrared background radiation (Hauser & Dwek 2001).

Of course, the Universe is not a finite Newtonian sphere. Radiation (electromagnetic, gravitational) which leaves one particular comoving volume does not disappear from the Universe – it enters its other parts. The total density ρ and the total pressure p are sums of several components, and the gravitational waves contribute to them. Neither ρ_{GW} nor p_{GW} are negative. Therefore, as the Friedmann equation shows,

$$\frac{\ddot{a}}{a} = -\frac{4\pi G}{3} \left(\rho + \frac{3p}{c^2} \right), \quad (1)$$

gravitational waves *always* contribute to *deceleration* of the expansion of the cosmological scale factor $a(t)$.

3 CONCLUSION

There is no gravitational repulsive force in General Relativity so it cannot contribute to the accelerated expansion of the Universe.

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¹ Equation (11) of their paper contains a printing error: in the denominator of the first LHS term there should be g_{00} instead of g_{11} .

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